# PORTABLE WATCH WITH RADIATION MONITOR

## TECHNICAL FIELD

The invention relates to combined personal devices in which the timekeeping components cooperate with radiation monitoring components whereby the watch not only displays time and other tune related data but also indicates the dosage of penetrating radiation to which the user is exposed and monitors the existing intensity of the radiation.

## BACKGROUND ART

Nowadays, many people live and work in the environment that may contain dangerous levels of radioactivity. The main feature of such radiation is that it is difficult to detect using small-size devices and the possibility of the living organism to accumulate radiation dose. Besides, exceeding of accumulated dosage can lead to fatal consequences - radiation sickness and heredity disorder.

Therefore, attempts were made to provide a human with personal device which is always at hand and can indicate not only the existing intensity of penetrating radiation to which the wearer is exposed but also the dosage of accumulated radiation thereof. One of the first engineering solutions relating development of such small-size devices was invention of compact wristwatch and radiation monitor assembly. The assembly consists of electronic timepiece with digital or analog display and a component which operates radiation monitor and contains semiconductor detector and controller. Radiometer is built on the basis of time computer microprocessor to adjust radiation monitoring with timekeeping.

Unfortunately, the above described device doesn't allow long-term precise monitoring of radiation. First, the semiconductor detector is not precise enough: it is responsive to other kinds of emanations, for example high-frequency radiation of mobile phones and other kinds of effects including mechanical effect. On the other hand, semiconductor radiation detectors consume much energy and the user has to

change power supply unit quite often. That is why the producer uses two independent power supplies for each component of the assembly.

The Yperwatch (Switzerland) [2] wristwatch was taken as a prototype for the watch and is the development of the well-known analogue. An analogue patent was taken out for this watch in Switzerland, Japan and other countries. The assembly consists of two components: electronic timekeeper with analog display where hands indicate the information and radiation monitor, which contains semiconductor detector and controller. This watch features at least two printed-circuit boards connected with each other by flexible conductor; the mechanism responsible for turning the analog hands of the watch is placed in the hollow on one of the printed-circuit boards.

The described above prototype is more fail-safe and practically feasible but doesn't solve the main problem. Semiconductor radiation detector is responsive to other, nonradioactive emissions, mechanical and climatic effects, besides it requires high-tension current. It is not possible to eliminate this weakness of semiconductor detectors in certain kind of equipment.

The monitoring of radiation can be done by means of Geiger-Muller counter, which is used in individual dosimeters. However, such devices have not been used in wristwatch and other compact devices till today because the Geiger-Muller counter requires constant voltage of about 400V.

The task of current invention is to use Geiger-Muller counter as a radiation detector in individual wristwatch and to ensure its functioning over a long period of time. A voltage changer able to change voltage from 1,5V – 3V to 400V is needed to make the Geiger-Muller counter function in wristwatch and other compact devices.

There is known a voltage changer containing energy source, for example: solar cell or solar battery, converter of direct current into alternating current by means of a switch key, electric transformer and AC/DC converter where switch key disjoins one or another winding and windings are made different so as to make it possible to adjust the output voltage [3].

The disadvantage of the known device and its implementation method lies in impossibility to adjust precisely the output voltage and rather high energy consumption.

A device for converting direct current into high-tension direct current was taken as a prototype for voltage changing method and voltage changer itself. The device has several outputs, pulse converter with controller which operates electronic switches, step-up transformer with AC/DC converter and filter where output voltage is forwarded to controller through devisor [4].

Disadvantage of the known device and its implementation method is that feedback leakage causes much energy consumption and for this reason the device fed by compact power supply unit can't keep functioning over a long period of time.

The object of current invention is to use Geiger-Muller counter as a radiation detector in individual wristwatch and to ensure its functioning over a long period of time.

## DISCLOSE THE INVENTION

This task is solved as follows: as per present invention, in the certain portable watch and radiation monitor assembly, consisting of a case, timekeeping and time indicating unit, radiation intensity measurement unit, radiation detector, control unit (micro controller), display unit and power supply unit, was installed Geiger-Muller counter functioning as a radiation detector and a voltage pulse converter for Geiger-Muller counter power supply; and the micro controller was connected to the voltage changer.

The problem put by is solved as follows: Geiger-Muller counter is provided with the additional switch key that is connected to micro controller and ensures measuring of radiation intensity in gating mode.

The problem is also solved by the fact that the watch incorporates additional power supply for separate feeding of the timekeeping/displaying unit and radiation intensity measurement unit.

Besides that, there was installed a Geiger-Muller counter actuation pulse former. The inlet of this pulse former is connected to low-voltage side of the power supply filter capacitor of the Geiger-Muller counter and its outlet is connected to micro controller.

The purpose of the invention is achieved also by installing filter-rectifier applying reference voltage from secondary coil tap of the transformer to cathode of the

Geiger-Muller counter.

The purpose is achieved also by the following: in known method of converting low voltage into high constant voltage involving converting of direct current into pulse current by means of electronic switch key, the rise of impulse voltage up to impulse voltage of the predetermined value by means of step-up transformer, with the subsequent rectification, stabilization and filtering of the achieved impulse voltage, as per current invention the return impulse voltage at primary winding is being compared with the predetermined value when the switch key opens and switch key control impulse frequency is being changed depending on the exceed of the return impulse voltage at primary winding over predetermined value, here switch key control impulses come from micro controller and an additional switch key control impulse is sent when the signal from the Geiger-Muller counter is received.

The purpose is achieved also as far as the return impulse voltage at primary winding is being compared with the predetermined value by means of threshold element.

The purpose of the invention is achieved also by the following innovation: as per current invention, in the known compact voltage changer, preferably for portable timepieces and devices, containing direct voltage source, unipolar transistor functioning as a disconnecting piece, step-up transformer, micro controller, rectifier and filter of the output voltage, as per current invention the threshold element, installed into primary winding, is connected to micro controller while micro controller data bus is connected to unipolar transistor base.

A new technical result was achieved after solving this problem: utilization of the Geiger-Muller counter in the above mentioned device increased its measurement precision. This device can be used not only for everyday purposes, but also as a standardizeв measuring device. Applying of the Geiger-Muller counter together with compact voltage changer controlled by micro controller according to pulse-frequency schema allows to essentially reduce current consumption and to prolong the functioning period of the device fed by one power supply item up to one year.

Besides that, providing the Geiger-Muller detector with additional switch key allows measuring of the radiation intensity not all the time, but only when the

additional switch key is opened in gating mode. Then the Geiger-Muller counter is enabled periodically and switches off directly after receiving the signal. If the signal from the Geiger-Muller counter wasn't received, the counter doesn't switch off during the next following period of time. Sum of periods of time starting from enabling the counter and ending at receiving of the signal per unit of time permits to calculate precise enough average radiation level. This technique makes it possible to reduce electric energy consumption by 80% during high radiation dose. Besides, to return the Geiger-Muller counter in a wait state some time is needed to stop the ionization, otherwise a high nonlinearity appears at high signal levels. Thus, switching the counter off for a certain part of the period permits to extend the measurement range and to increase measurement precision in different measurement ranges.

Applying of the new method of converting direct voltage into stabilized high direct voltage together with applying of the Geiger-Muller counter as a secondary winding load of the transformer helps to solve the problem put by.

## DESCRIBE THE FIGURES

The invention is illustrated by figures.

Fig.1 – general view of the assembly.

Fig.2 - functional scheme of the assembly.

Fig.3 - functional scheme of the assembly with extended measurement range (additional switch key on the detector).

Fig.5 - principle circuit of the assembly with simplified principle of operation.

Fig.6 - principle circuit of the assembly with simplified principle of operation but with different signal pickup if compared to Fig.5.

Portable watch with radiation meter and compact voltage changer consist of framework 1 of the device with placed on it under glass (not shown) clock-face 2 having different sections for displaying different alphanumerical and analog information. Thus, section 3 displays numerical information and operating mode of the device. Section 4 displays accumulated radiation dose, the intensity of the radiation is displayed on pseudo-analog scale in section 5. Hands 6 of the clockwork 7 are constantly indicating time. Buttons 8 manipulate the watch. The device consists of the following functional units. The whole device is operated by micro controller 9 (MC),

which operates switch keys 10 (SK) and 11 (SK1), as well as sound signaling device 12 (SSD) and infra-red transceiver 13 (IR) providing communication between the device and computer (not shown).

Besides, micro controller 9 receives signals from threshold device 14 (TH) and signals from the Geiger-Muller counter 16 (GC) that pass through pulse former 15 (PF). The switch key 10 is placed in the winding of transformer 17 (TR). The latter is connected to threshold device 14 and rectifier with filter 18 (RF). Voltage from the latter is passed to the Geiger-Muller counter 16. The device has power supply unit 19 (PS). Micro controller 9 drives the gear train 20 (GT) that turns the analog hands 7 of the watch. Buttons 8 command the micro controller 9. To speed up the functioning of the device, there is a rectifier- filter 21 (RF1) which inlet is connected to secondary winding of transformer 17 and which outlet is connected to negative electrode of the Geiger-Muller counter 16.

## THE BEST MODE CONTEMPLATED

The device functions as follows. Micro controller 9 operates all components of the device. Micro controller 9 forms impulses for operating the switch key 10 of the high-voltage transformer, receives and processes pulse pattern coming from the Geiger-Muller counter 16, calculates the measured values of minimum effective dose (MED) and effective dose (ED), compares measured values of (MED) and (ED) with the predetermined values and yields a sound signal to sound changer 12, if they exceed the predetermined values. Micro controller 9 operates also the inward clock, calendar, alarm, carries out commands received from control buttons, controls running regime of the liquid-crystal display (3, 4, 5), checks condition of power supply units of the device.

To provide functioning of the gas-discharge Geiger-Muller counter 16, there is a transformer which converts direct low voltage U = 3v into high voltage U = 400v. The converter consists of: micro controller 9, switch key 10, transformer 17, rectifier with filter 18, threshold device14. High voltage converter is made by scheme of the single-ended converter with reverse connection of rectifier diode. Besides, there is applied the mode of discontinuous currents in the winding of transformer.

Micro controller 9 sends control pulse to switch key 10. When the switch key is

opened, current pulse accumulates energy in primary inductance of the transformer 17. Rectifier diode of the rectifier 18 is locked at that moment. Current accumulates in accordance with the law, which is determined by the primary inductance value, while the constancy of voltage at the detector 16 is maintained by filter 18 capacitor. When the switch key 10 is closed, voltage sign at the secondary winding of the transformer changes and the early accumulated energy passes through rectifier diode 18 to the load and charges the filter 18 capacitor. Thus, transmission of energy from power supply to the load is carried out in two steps; each of the steps is realized in separate time-span.

To stabilize the high voltage level, we used method of invariant stabilization, i.e. absence of closed output voltage deviation control loop. Its stability is maintained by means of indirect parameter actuating path, in our case there are two parameters: parameter a) – by impulse value of the reverse motion on the primary winding of the transformer 17 and parameter b) – by change in speed of counting impulses that come from the Geiger-Muller detector 16. This method permits to delete feedback circuit with leakage and to considerably prolong the period of functioning of the power supply unit.

The threshold device 14 is used to control the high voltage level by parameter a). The threshold device 14 compares impulse value of the reverse motion on the primary winding of the transformer 17 with the threshold value. Micro controller 9 functions as pulse-frequency modulator. When the level of the impulse of the reverse motion on the primary winding of the transformer 17 gets below the threshold value, the repetition rate of switch key control impulses rises. When the level of the impulse of the reverse motion on the primary winding of the transformer 17 exceeds the threshold value, the repetition rate of switch key control impulses reduces.

The Geiger-Muller counter 16 readings are used to regulate the high voltage level by parameter b). When micro controller 9 receives impulse from the Geiger-Muller counter 16, it generates control impulse for switch key 10. This path provides stable operation of the transformer when there are dynamic load changes. It's obvious, that puncture of the Geiger-Muller counter causes discharge of the capacitor 18 and bucking effect in counter power supply unit. This demands immediate voltage buildup at capacitor 18 and micro controller 9 immediately sends control impulse to switch key 10.

Impulses come from the Geiger-Muller counter 16 to pulse former 15. Pulse former converts impulses from Geiger-Muller counter into impulses of the required shape so that to make it possible for micro controller 9 to process them (Fig.6).

Scheme (see Fig.5) of the signal pickup from Geiger-Muller counter 16 anode is used for special detectors which provide a wider range of dose intensity measurements thanks to reduction of circuit capacitance. The last scheme can be supplemented with switch key 11 to even more widen the range of the device measurable rates of radiation.

High voltage control circuit consists of micro controller 9 (MC), switch key 10 (SK), transformer 17 (TR) and threshold device 14 (TD). Switch key 10 (SK) and transformer 17 (TR) operate per circuit of the reverse motion transformer. This functions as follows: during the first stage (forward trace) micro controller 9 generates logical unit level which opens switch key 10. At the same time linearly increasing current flows through the primary winding of the transformer. During the second stage (reverse motion) micro controller 9 generates logical zero unit, switch key 10 closes, current flows through the secondary winding of the transformer and charges the accumulating capacity of the filter 18 (RF). Tension of the primary winding is proportional to tension of the filter capacity. Voltage regulator diode of the threshold device 14 (TD) is closed till the tension reaches operation value. Transistor of the threshold device is closed as well. During the reverse motion, micro controller 9 analyses operating condition of the threshold device 14 and if the operating tension hasn't reached the required level, the whole procedure is repeated. When during the reverse motion operating tension at the outlet of the rectifier 18 reaches the required level, voltage regulator diode of the threshold device opens, negative polarity pulse is generated on the capture anode of the transistor and it sends signals to micro controller 9 to stop the process of pumping of high tension. The peculiarity of the threshold device circuit is that it consumes energy only during a very short period (about 2 microseconds) of reverse motion impulse and only after the operating level of high tension is reached. The rest of the time transistor of the threshold device is closed and power supply energy is not used.

Automatic control of how often the high tension is being pumped is done in the following way. Micro controller clears pulse counter before the subprogram of high

tension pumping starts running. Then micro controller counts how many impulses there should be in the pulse burst to reach the required operating level of high tension on the outlet capacitor of the filter. If this value N exceeds the maximum fixed $N_{max}$, the interval between pulse bursts is shortened, and vice versa, if N doesn't reach $N_{min}$, the interval is longer. Finally, an optimal pulse repetition rate is determined, this permits to compensate leakage in rectifier, filter and Geiger-Muller counter. There is little energy needed. Additional subprogram of micro controller permits to compensate energy loss in the accumulating capacity of the filter caused by ingress of gamma-quantum into the counter. The subprogram is started immediately after detection of impulse from the Geiger-Muller counter by the micro controller.

Circuit of signal pickup from the Geiger-Muller counter 16 (Fig.5) is used for special sensing devices which provide a wider range of dose intensity measurements. Switch key 11 serves for compulsory switch-off of the Geiger-Muller counter 16. micro controller 9 by means of the switch key 11 periodically switches on the counter 16, and switches it off immediately after receiving the signal. Such switch on pattern permits to reduce the influence of "idle" time and of the recovery time of the counter. "Idle" time – time, during which one gamma-quantum ionizes in the counter and if other gamma-quantum gets into the counter at that time, it doesn't produce any changes.

The result of using the additional switch key 11 is that the device can measure dose intensity in a wider range.

Rectifier- filter 21 (RF1) takes from the part of the secondary winding of the transformer additional tension level which is close to the operating level and applies it to the cathode of the Geiger-Muller counter (16). This fastens the process (saves time) of switching on and ensures the switch-off of the counter when the switch key 11 is opened. Pulses from the Geiger-Muller counter are intensified by pulse former 15 the latter being a fast amplifier cascade with the common emitter. Basic diode of the pulse former 15 transistor is shunted by the diode through which the charge of high-voltage rectifier 18 capacitor flows. Then the signal from the output of the pulse former comes to the counting input of the micro controller 9.

By means of buttons 9, micro controller is commanded to display numerical information in the section 3 of the face of the watch. Here is displayed calendar,

current time, the accumulated radiation dose.

The watch can incorporate an infra-red transceiver 13 (IR) which provides communication between the device and computer. In this case when the wearer passes an infra-red computer interface, the device connects to the computer and offers information on the wearer and the current accumulated dose.

The applicant for a patent finished development works and prepares documentation for line production of the personal wristwatch and radiation meter assembly based on Geiger-Muller counter. Research revealed that the device ensures high accuracy of measurement and the functioning period of the device fed by one power supply item is up to one year.

Sources of information, taken into account during the expertise:

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